CLAIMS

1. Stirrup for reinforcing load bearing elements having main reinforcement rods, which stirrup comprises [consisting of] a plurality of consecutive windings **(7a, 7b)** disposed along the longitudinal direction of the stirrup and has a continuous cross-section, so that the stirrup has a spiral form, whereby the windings of the stirrup form a plurality of discrete cages **(5a, 5b)** [to house] for housing the main reinforcement rods (**1a, 1b**) of the load bearing element.

2. Stirrup **according to claim 1,** whereby the stirrup comprises n cylindrically- or approximately cylindrically-shaped cages, where n is an integer greater or equal to 2, and whereby the projections of each n-th winding provided along a portion at least of the length of the stirrup, on a transverse plane coincide.

3. Stirrup **according to claim 1 [or 2],** whereby the stirrup comprises two **[and only two]** cages to house the main reinforcement rods of the load bearing element.

4. Stirrup **according to claim 1 [or 2],** whereby the stirrup comprises at least four cages (**5a, 5b, 5c, 5d**) to house the main reinforcement rods of the load bearing element.

5. [Stirrup **according to any of the proceeding claims,** whereby the projection of the stirrup on a transverse plane coincides to the cross section of a load bearing element comprising at least one web and at least one flange.]

6. Stirrup **according to claim 1, [any of the claims 1, 2, 3, 5]** whereby the shape of the windings on a transverse plane is orthogonal and adjacent windings are so disposed, that the long dimension of each winding is

normal to the long dimension of its adjacent windings, so that the projection of the stirrup on the transverse plane is T like.

7. Stirrup **according to claim 1 [or 2]**, whereby [in that] the stirrup comprises [an outer cage which houses all other cages of the stirrup] a plurality of cages and whereby one of the said plurality of cages houses the other of the set plularity of cages.

8. Stirrup **according to claim 1 [any of the preceding claims]**, whereby the stirrup is made of a continuous extruded steel rod.

9. Stirrup **according to claim 1 [any of preceding claims]**, whereby the stirrups are made from composite material.

10. Stirrup **according to claim 1 [any of proceeding claims]**, whereby the windings are disposed on substantially transverse planes and consecutive windings are joined by substantially longitudinal elements.

11. Stirrup **according to cliam 1 [any of preceding claims]**, whereby the distance between consecutive windings is uniform.

12. Stirrup **according to claim 1 [any of preceding claims]**, whereby the distance between consecutive windings is variable.

13. [Stirrup **according to any of preceding claims**, whereby the stirrup comprises two spiral elements (**3', 3''**) disposed longitudinally and joined at their ends, so that the one of the two elements extends towards one side of the said joined ends and the other of the two elements extends towards the other side of the said joined ends.

14. Stirrup **according to claim 13**, whereby the two spiral elements is welded together.

15. Stirrup **according to claim 13 or 14**, whereby the first and/or the second of said elements are stirrups **according to any of the claims 1 to 12**.]

16. A prefabricated load bearing element comprising a stirrup **in accordance with any of the claims 1 to 15**.

17. Method of reinforcing of shear wall elements using at least two of the stirrups of **any of the claims 1 to 15** [, whereby the reinforcement of the wall is effected by joining at least two of the said stirrups with reinforcement rods (**4**)].

18. [Method of reinforcing a load bearing element whereby the principle rod elements of the reinforcement are housed within the windings of a spiral shaped stirrup, and whereby the stirrup comprises a plurality of cages **(5a, 5b)**, with each cage **(5a, 5b)** tightening a different set of principal rod elements.

19. A load bearing element whereby the principle bar elements of the reinforcement are housed within the windings of a spiral shaped stirrup whereby the stirrup comprises a plurality of cages **(5a, 5b)**, with each cage **(5a, 5b)** tightening a different set of principal rod elements.]

1. [Stirrup for reinforcing load bearing elements consisting of a plurality of consecutive windings **(7a, 7b)** disposed along the longitudinal direction of the stirrup, so that the stirrup has a spiral form, characterized in that the windings of the stirrup form a plurality of discrete cages **(5a, 5b)** to house the main reinforcement rods (**1a, 1b**) of the load bearing element.]

18. Method of reinforcing a load bearing element comprising at least two sets of reinforcement rod elements, whereby the method includes the step of providing [whereby the principle rod elements of the reinforcement are housed within the windings of] a spiral shaped stirrup with a continuous cross-section and a plurality of consecutive windings, which windings form [characterized in that the stirrup comprises] a plurality of cages **(5a, 5b)**, with each cage **(5a, 5b)** tightening a different set of [principal] reinforcement rod elements.

19. A load bearing element comprising at least two sets of reinforcement rod elements and [whereby the principle bar elements of the reinforcement are housed within the windings of] a spiral shaped stirrup with a continuous cross-section and a plurality of consecutive windings, which windings form [characterized in that the stirrup comprises] a plurality of cages **(5a, 5b)**, with each cage **(5a, 5b)** tightening a different set of principal rod elements.

ANNEX II

09/331,805

ANTISEISMIC SPIRAL STIRRUPS FOR REINFORCEMENT OF LOAD BEARING STRUCTURAL ELEMENTS

CROSS REFERENCE TO RELATED APPLICATIONS

This application is the national phase of International Application No. PCT/GR97/00043 filed on December 31, 1997 and designating, *inter alia*, the United States. International Application No. PCT/GR97/00043 claims priority from Greek Patent Application No. 970100003 filed on January 3, 1997.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention refers to stirrups for reinforcement of load bearing structural elements, and in particular for reinforcing concrete load bearing building elements, such as columns, shear walls, beams, slabs, footings, lintels, piles. The invention refers also to a method for reinforcing structural elements as well as to these elements.

2. Description of the Prior Art

Stirrups and ties constitute one of the most critical factors of quality and antiseismic strength of buildings. Essential factors for the liability of stirrups are the proper hooks at their ends and the bend diameter at corners. The hooks at the end of the conventional stirrups are absolutely necessary for ensuring the proper functioning of the stirrup or tie in case of a very strong earthquake, when the spalling of the concrete occurs and when the hooks is the only remaining anchorage mechanism.

The following stirrups are used in building industry today:

i) Individual stirrups **8**, which may be of various forms, such as described in **figure 1**. For individual stirrups it is essential to be fastened in a plurality of points to the principal reinforcement rods **1** of the reinforcement as well as to

the woodform. Thus their assembly is complicated and has a high cost. The individual stirrups **8** comprise hooks **6**, for anchoring the stirrups to the load-bearing element of the structure.

ii) "Mantles", i.e. stirrup cages made of prefabricate welded meshes (**see figure 2**). These are made of standardised welded meshes in suitable machines. The partial replacement of common stirrups by the "mantles" or "stirrup cages" was the first attempt to transform the painful task of reinforcing the load bearing elements of the structure into an industrial process. However the manufacture of the mantles is done in two phases, and only part of the process may become an industrial one: The first phase is an industrial process aiming in the production of plane meshes, such as shown in **figure 3**, from steel rolls using huge machines. During the second phase the meshes are almost manually assembled to form stirrup cages. The production of 'mantles" have the following limitations: a) it is difficult to manufacture compound stirrup shapes by analysing them in simple rectangular shapes, b) it is impossible to increase or decrease the spacing of the stirrups resulting in superfluous weight of the reinforcement, c) it is expensive to transport them due to the size of the cages, d) it is difficult to manufacture double hooks, which is a necessity in antiseismic structures, and e) there is a danger of buckling of the vertical binding bars in case of an earthquake.

iii) Circular or orthogonal spiral stirrups such as disclosed in EP-A-0152397. Numerous experiments have been executed with circular spirals, which proved that if the spacing of the windings, i.e. the pitch, is kept below a minimum distance, the spirals are actually functioning like steel closed mantles, whose strength is increased due to the presence of triaxial stress system. The spiral stirrups currently known are appropriate only for reinforcing columns with rectangular cross-section. Further they are uneconomical because of the constant spacing between windings, which is determined by the shear level at the most critical region of the member. They also present problems in manufacturing and difficulties in placing them by the skilled workmen, because

of the excessive weight in cases of strongly reinforced columns with many sides.

SUMMARY OF THE INVENTION

An object of the present invention is a stirrup overcoming the problems of the known stirrups. A further object of the invention is a stirrup which may be used for reinforcing load bearing elements of various cross-sections such as columns, shear walls, beams, slabs, footings, lintels, piles.

An object of the invention is also a method for reinforcing the load bearing elements of a structure as well as such an element.

The stirrup for reinforcing load bearing elements, in accordance with the invention, comprises a plurality of consecutive windings disposed along the longitudinal direction of the stirrup and has a continuous cross-section, so that the stirrup has a spiral form, whereby the windings of the stirrup form a plurality of discrete cages for housing the main reinforcement rods of the load bearing element.

The method of reinforcing a load bearing element, according to the invention, comprising at least two sets of reinforcement rod elements, includes the step of providing a spiral shaped stirrup with a continuous cross-section and a plurality of consecutive windings, which windings form a plurality of cages, with each cage tightening a different set of reinforcement rod elements.

A load bearing element, according to the invention, comprises at least two sets of reinforcement rod elements and a spiral shaped stirrup with a continuous cross-section and a plurality of consecutive windings, which windings form a plurality of cages, with each cage tightening a different set of principal rod elements.

[A stirrup for reinforcing load bearing elements according to the invention consists of a plurality of consecutive windings disposed along the longitudinal

direction of the stirrup, so that the stirrup has a spiral form, whereby the windings of the stirrup form a plurality of discrete cages to house the main reinforcement bars of the load bearing element.

In accordance with a method of the invention for reinforcing a load bearing element, the principle bar elements of the reinforcement are housed within the windings of a spiral shaped stirrup whereby the stirrup comprises a plurality of cages, with each cage tightening a different set of principal bar elements.

A load bearing element according to the invention, comprises principle bar elements housed within the windings of a spiral shaped stirrup, whereby the stirrup comprises a plurality of cages, with each cage tightening a different set of principal bar elements.]

Stirrups in accordance with the invention have a spiral form, so that the axial load carried by the stirrup may continuously transmitted with no interruption along its length. The windings of the stirrups of the invention form more than one cages for the principal reinforcement rods, so that they may be used for the reinforcement of load bearing elements of various cross sections such as orthogonal, T-shaped, L-shaped, Z-shaped etc. The stirrup may be brought in site compressed, and stretched during its positioning around the principle reinforcement rods. Its attachment to the reinforcement rods requires a relatively low number of fastenings – it is enough to fasten each winding to four or even three principle reinforcement rods - and involves relatively a low cost. The use of the stirrups of the invention allows the manufacture of the transverse reinforcement, which is essential for antiseismic and other reasons, to become an industrial process with low manufacturing cost and high quality of the product.

Stirrups according to the invention may be manufactured from a steel grade with very high strength, for example S1200 (1200MPa), because there is no need to use hooks for anchoring, which are usually the weak points of the known stirrups. A further advantage of the stirrups of the invention is that their

production and the stirrups themselves, may be standardised so that they may be of high quality and they could be used for reinforcing standard types of load bearing elements.

The [further] features of the invention described in the dependent claims offer [other] further advantages.

[According to claim 2, the windings of the stirrup are periodically arranged, so that each cage is formed by every n-th winding where n is the number of cages.

The stirrup of claim 3 has exactly two cages. With such an arrangement it is possible to cover the reinforcements of a large number of load bearing elements.

The stirrup of claim 4 has at least four cages. Such a stirrup is adequate for load bearing elements having a relatively large number of principal reinforcement rods and/or relatively complicated cross-section.

Preferable shape of stirrups are defined in claims 5, 6, 7. According to claim 5 the stirrup has a cross section similar to the cross section of a load bearing element having at least on web and at least one flange. Such a cross section may be T, Z, double T or other.

Claims 8, 9 define preferable materials to be used for the production of the stirrups of the invention.

The preferable advancement of the windings in the longitudinal direction according to claim 10 renders the stirrup advantageous in the case of relatively high shear loads.

Claim 11 defines that the distance between consecutive windings is uniform, while according to claim 12 the pitch may vary. Thus more economically effective solutions are possible.